Time and Space Resolved Optical Plasma Diagnostics of Table-Top Scale Laser Produced Tin Plasmas

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Abstract

•The work presented here gives an introduction to an optical plasma diagnostics study of Sn Laser Produced Plasmas in selected configurations.

•The specific aim is to generate density-temperature maps for various laser power densities, wavelengths and target geometries to compare with values from predictions for optimised EUV emitting parameter sets.

Experimental Setup

- Dedicated Lab for LPP Diagnostics
- Surelite™ Nd:YAG laser beam operated at it's fundamental (1064nm) or harmonics (532nm, 335nm, 266nm)
- 0.5m Chromex™ UV-Vis Czerny-Turner mount
- AndorTM ICCD operated in 2D (imaging mode) with a minimum gate width of 3 ns [1 – 3].

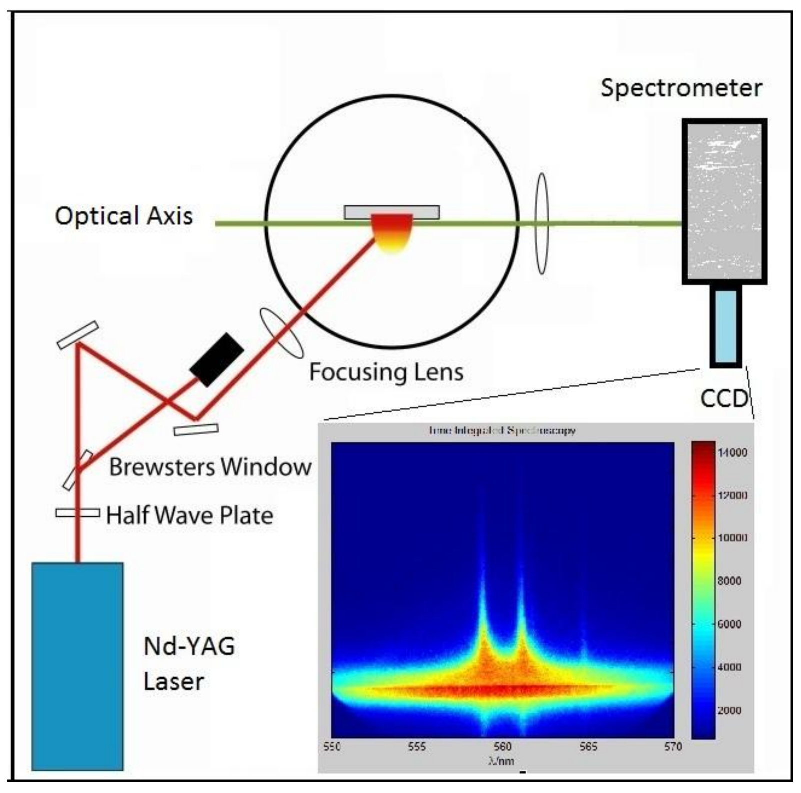

Fig 1. LPPS setup. Laser energy and target geometry can be varied to optimise plasma conditions

Analysis

Temperature

The electron excitation temperature can be determined using the ratio of the intensities between spectral lines from two successive ion stages of the same element. The population distribution across the ion stages can be described by the Saha equation. Thus the ratio of the intensity from two consecutive ion stages is given by [4]

$$\frac{I_1}{I_2} = \frac{f_1 g_1 \lambda_2^3}{f_2 g_2 \lambda_1'^3} (4\pi^{3/2} a_0^3 n_e)^{-1} \left(\frac{k_b T_e}{E_H}\right)^{3/2} exp\left(\frac{-E_1 + E_2 - E_\infty + \Delta E_\infty}{k_b T_e}\right)$$

Electron Density

The Stark effect is dependent on the electron density, and so the spatial distribution of the electron density (ne(x)) can be determined by the position dependent magnitude of both the Stark shift and Stark broadening for each spectral line(which can be obtained from literature). The Stark broadening and shift of the spectral lines is related to the electron density by the following simplified equations:

$\Delta\lambda$width(x) = w n_e((x)

$\Delta\lambda$shift (x) = dn_e(x)

The Stark broadened profiles are approximately Lorentzian and can be fitted to the experimental data

Imaging

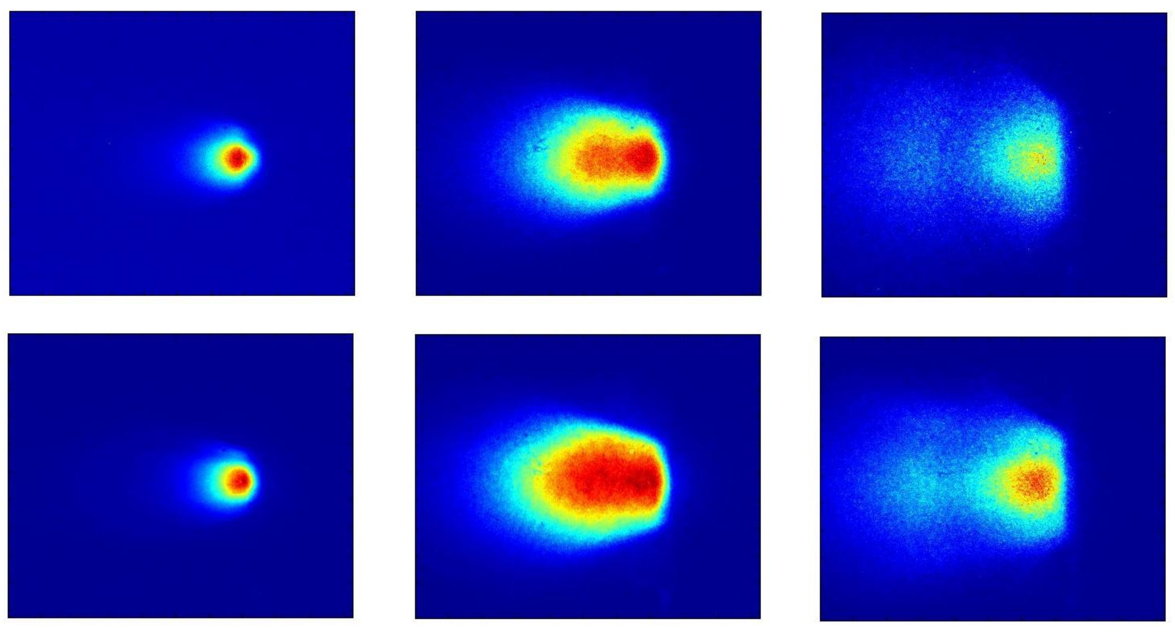

***Fig 2:** Imaging of a flat target. The upper images show an LPP created by a 500mJ pulse. The lower images were created using a 750mJ pulse. From l to r each was recorded at 150ns, 250ns & 400ns after the peak of the laser pulse hit the target. NB: different gains for each image*

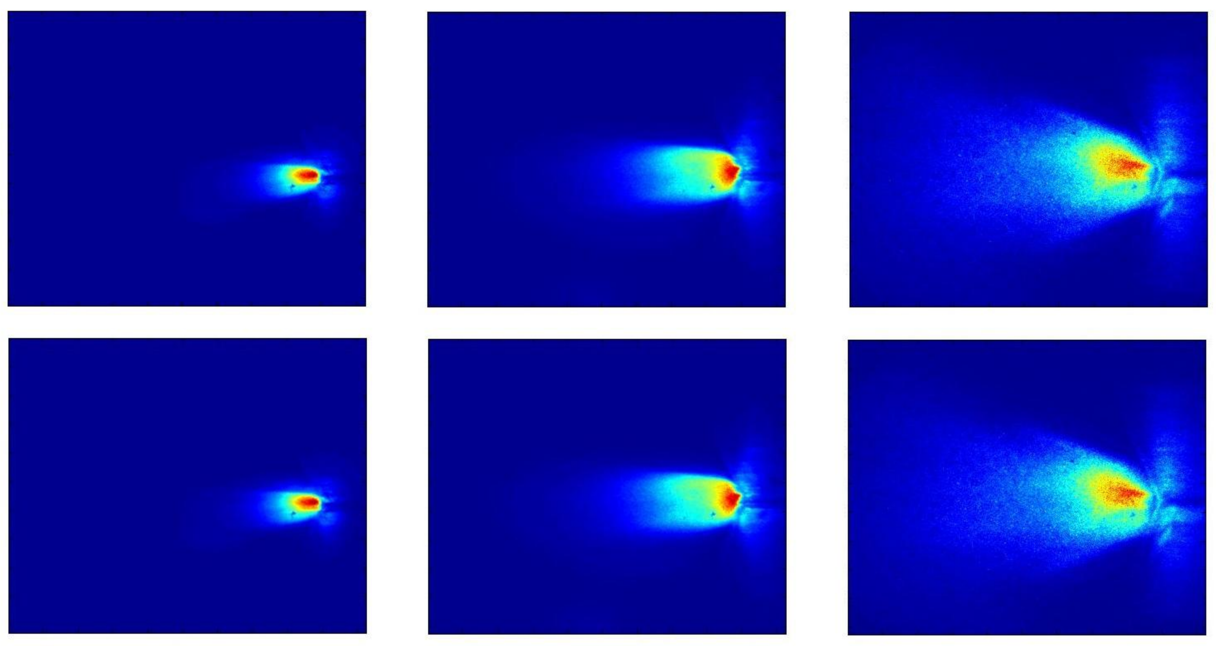

***Fig 3:** Imaging of a 140 degree open angle wedge target. The upper images show an LPP created by a 500mJ pulse. The lower images were created using a 750mJ pulse. From l to r each was recorded at 150ns, 250ns & 400ns after the peak of the laser pulse hit the target NB: different gains for each image*

Spectroscopy

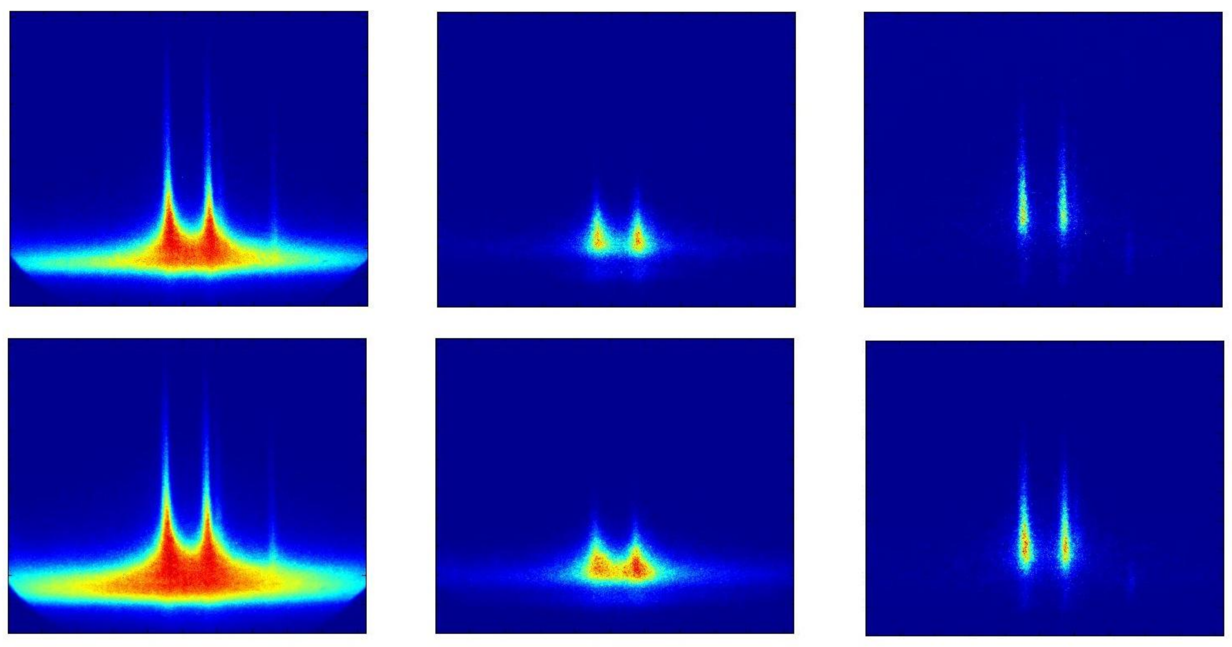

***Fig 4:**Spectroscopy of a flat target. The upper images show an LPP created by a 500mJ pulse. The lower images were created using a 750mJ pulse. From l to r each was recorded at time integrated, 150ns & 250ns after the peak of the laser pulse hit the target.*

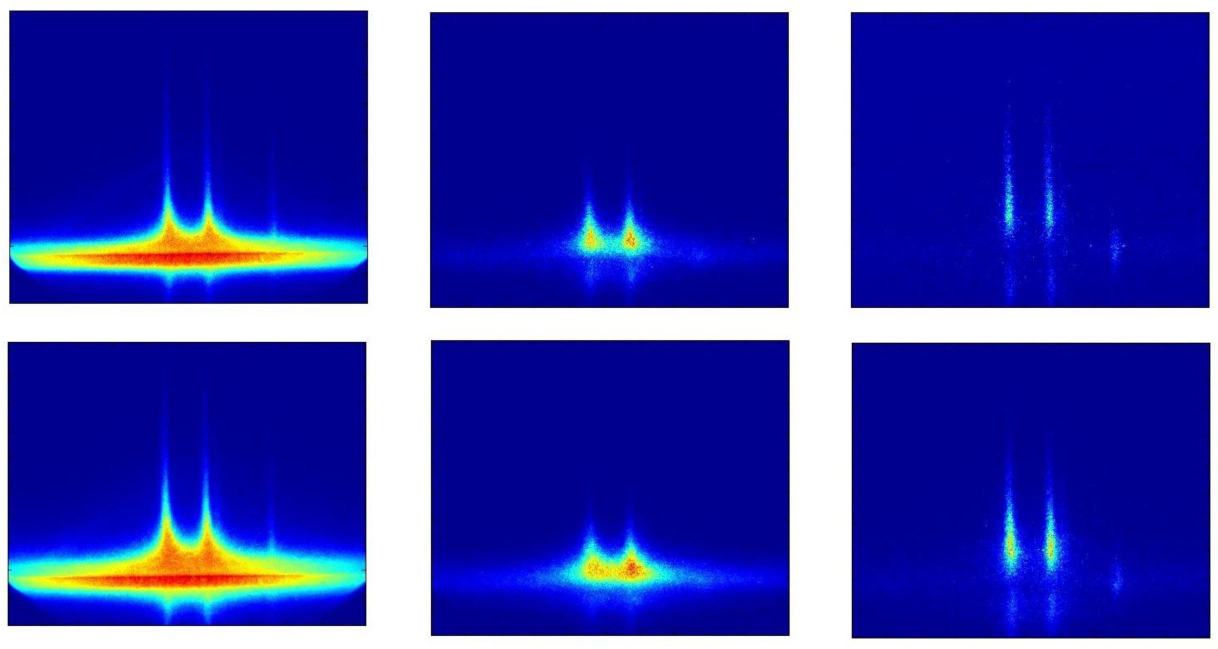

***Fig 5:**Spectroscopy of a 140 degree open angle wedge target . The upper images show an LPP created by a 500mJ pulse. The lower images were created using a 750mJ pulse. From l to r each was recorded at time integrated, 150ns & 250ns after the peak of the laser pulse hit the target.*

References

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